A.D. 1866, 17th JULY. N° 1867.

Electric Telegraph Apparatus.

LETTERS PATENT to Cornelius Varley, of 337, Kentish Town Road, in the County of Middlesex, and Samuel Alfred Varley, of 66, Roman Road, Holloway, in the said County of Middlesex, Telegraph Engineers and Contractors, for the Invention of "IMPROVEMENTS IN ELECTRIC TELEGRAPH APPARATUS."

Sealed the 14th December 1866, and dated the 17th July 1866.

PROVISIONAL SPECIFICATION left by the said Cornelius Varley and Samuel Alfred Varley at the Office of the Commissioners of Patents, with their Petition, on the 17th July 1866.

We, CORNELIUS VARLEY, of 337, Kentish Town Road, in the County of Middlesex, and SAMUEL ALFRED VARLEY, of 66, Roman Road, Holloway, in the said County of Middlesex, Telegraph Engineers and Contractors, do hereby declare the nature of the said Invention for "IMPROVEMENTS IN ELECTRIC TELEGRAPH APPARATUS," to be as follows:—

Our Invention consists in an improved method of constructing single and double needle instruments and other telegraph apparatus, these improvements having for their object greater durability on the part of the instruments and less liability to derangement, either from mechanical causes or from being struck by lightning, and greater sensitiveness to feeble electric currents.

We make the outer cases of our needle and other analagous telegraph instruments which heretofore have been made of wood of cast iron, and the bush or bearing in which the axle works in one piece with the case. The axle is made of gun metal or any other suitable metal, and is constructed with a square on one end for the instrument handle to fit on to, and with a transverse piece at the other end which is usually made in a line with the handle. Two holes are bored in the upper end of the transverse piece at the sides, and two insulating pins are fitted into these holes; these pins project a little way on both sides. What is technically known as the bridge of the needle instrument is fixed a little above the top of the transverse piece. Two upright springs, which we call Nos. 1 and 2, press against the bridge on either side; these are attached at the lower end to blocks of metal, and in some cases to blocks of wood. When the handle of the instrument is moved over to the right-hand side spring No. 1 is removed from contact with the bridge by means of one of the pins. When the handle is moved to the left-hand side springs No. 2 is removed from the bridge by the insulated pin fitted into the other side of the transverse piece; when the handle is vertical both Nos. 1 and 2 springs press against the bridge. We prefer in most cases, instead of letting the lower end of the transverse piece come in direct contact with the metal blocks as before described, to extend the metal blocks downwards some distance (4 inches will be sufficient) and attach springs, which we call Nos. 5 and 6, to the sides of the blocks for the transverse piece to beat against; the upper parts of Nos. 5 and 6 springs come into contact with the transverse piece when the instrument handle is moved; the lower ends of these springs are attached to the bottom of the blocks. A recess is cut into the sides of the blocks to allow Nos. 5 and 6 springs to be pushed in a definite amount; their motion in the other direction is also limited by so fixing Nos. 1 and 2 springs to their respective blocks that their lower ends lap a little way over the upper ends of Nos. 5 and 6 springs. The bridge and Nos. 1, 2, 3, 4, 5, and 6 springs and blocks attached to them are insulated from the iron case. The plan we prefer for doing this is to take a piece of well seasoned wood which has been soaked for a time in melted paraffine or hot linseed oil and cut a hole through it to allow the axle bush which projects a little distance in the inside of the case to pass through. We fit the blocks carrying the springs and the bridge on to this slab of wood; we then take another piece of wood of a similar size, but much thinner, and place it behind the board on which the work has been fitted. Both pieces are then placed into the cast-iron case and bolted to it; ebonite may be employed in place of wood for insulating the different parts.

The different portions of the instrument are connected as follows:—No. 1 spring is connected to a terminal or binding screw which we call B; No. 2 spring is connected to one end of a galvanometer coil, the other end of the galvanometer coil is connected to a terminal called A; Nos. 3 and 4 springs are connected to a terminal called Z, the axle is connected to a terminal called C. All these terminals, with the exception of C, are insulated from the iron case.

The instrument is connected up as follows:—If the instrument be fixed at a terminal station terminal B is connected with the line, and terminal A to the earth, or vice versâ; if the instrument be placed at an intermediate station, A is connected to the line wire on one side of the station, and B to the line wire on the other side of the station; terminal C is connected to the copper pole of a galvanic battery, and Z with the zinc pole of the battery. When a current is being received it passes from the line wire to terminal B, through the galvanometer (deflecting the needle) to No. 2 spring across the bridge to terminal A, and thence to the earth. When sending a current if the handle be moved to the right No. 1 spring is pressed away from the bridge and against spring No. 3, which is connected to the zinc pole of the battery; the lower end of the transverse piece which is connected through the metal case to the copper pole of the battery is brought into contact with the block of metal attached to No. 2 spring, and a positive current is sent through the galvanometer on to the line wire connected to terminal B. When the handle is moved to the left the zinc pole is brought into contact with No. 2 spring and the copper pole with No. 1 spring, and consequently a negative current passes along the line.

We construct our galvanometers as follows:—We wrap the coils on frames or bobbins with moveable cheeks so that after the coils are wrapped the bobbin on which the wire has been wrapped can be removed; these bobbins are made in the shape of segments of a circle. After the coils have been wrapped they are immersed for a time in a bath of any suitable melting cement; they are then removed from the bath and the bobbins carefully taken to pieces, the wires retaining their position by the adhesion of the cement. The coils are then placed in a mould of the shape the coils are intended to be when finished and compressed; this brings the convolutions closer together and forms them into segments of a circle; when the cement has hardened by being cooled the coils are removed from the mould and placed in a circular chamber or box. The coils being segments of a circle pack closely together. The coils are of such a length that they do not reach to the centre of the circular box, but leave a central space. In this space and at right angles to the circular box the pole of a powerful permanent magnet is inserted. A circular soft iron disc with soft iron bars radiating from it is mounted on an axle over the pole of the permanent magnet. The radiating bars are made of iron numbers so that they may be opposite one another, and pass over the surface of the segmental coils; the axle terminates in a fine pivot which works in a pivot hole made in the pole of the permanent magnet. The soft iron disc and its radiating bars become magnetic by induction from the permanent magnet underneath, and all the bars being magnetized in a similar way there are practically astatic. To prevent the friction in the pivot hole, which would be caused by the inducing magnet pulling the iron disc towards it, a second iron disc with radiating bars exactly similar to that before described is mounted on the same axle higher up; this second disc is so mounted on the axle that if a perpendicular line be dropped from the upper radiating bars when the axle is vertical it will pass exactly between the bars radiating from the lower disc; over the upper disc another permanent magnet is mounted which magnetizes it and the bars radiating from it by induction, and there is also an arrangement by means of which the pole of the upper permanent magnet can be adjusted nearer or further from the upper disc; by raising or lowering this adjustment the astatic forces of the upper and lower permanent magnets on the soft iron discs can be balanced. The number of radiating bars in each disc is half that of the coils, that is to say, if there be 12 segmental coils, each occupying a space of 30 degrees, there will be radiating bars in each disc 60 degrees apart from one another on their respective discs. The lower soft iron disc is generally mounted below the surface of the coils, and the radiating bars are first bent at right angles or nearly so to the disc, and then bent again so as to move in a plane over the surface of the coils. The radiating bars of the upper disc are also bent so that they move in the same plane over the surface of the coils as the radiating bars of the lower disc, and being exactly between them; the distance between the radiating bars of the upper and lower discs is 30 degrees, and consequently there is a radiating bar over each coil. The inducing pole of the upper permanent magnet is of the opposite polarity to that of the lower permanent magnet, the radiating bars are therefore magnetized alternately north and south. The segmental coils are also so joined up that when an electric current is sent through them the centres of the coils become alternately south and north. A second series of segmental coils can be arranged over the upper surface of the radiating bars to increase the force of the electric currents. When an electric current is sent through the coils the radiating bars arrange themselves over the centres of the coils according to the direction of the electric current, and being highly magnetic, and at the same time not influenced by the earth's magnetism, the instrument is very sensitive. The sensitiveness of the instrument can be still further increased by fixing a mirror on the axle carrying the discs, and reflecting a beam of light on a screen. In some cases we make the radiating bars of magnetized tempered steel, and do away with the inducing magnets, but where great sensitiveness is required we prefer using soft iron radiating bars and inducing magnets, and when we desire the greatest possible sensitiveness we replace the permanent inducing magnets by electro-magnets. This galvanometer forms a very good relay for working Morse printing instruments or for relay transmission; when we use it for this purpose we mount a light metallic arm on the axle carrying the soft iron discs, having a piece of platina or platina alloy fixed to it where it touches the contact points. This relay works between two contacts in a similar way to what are known by the name of polarized relays, but instead of using fixed points for the relay arm to beat against we mount small wheels or rollers made of gold or platina alloy; motion is communicated to these wheels by two hard rollers made of bell metal or other hard non-magnetic metal rolling against them. These bell-metal rollers are driven by means of a simple piece of clockwork, which we prefer being made entirely of brass or other non-magnetic metal. The gold rollers revolve in the same plane as the relay lever, and when the contact lever beats against them any film of air adhering to the roller is wiped away and better contact made, the lever is also less liable to stick than in other relays when working with very weak currents; the object of communicating the motion by another roller is that it burnishes down the roughness caused by the electric current melting the metal at the point of contact. When the galvanometer is intended for currents of large dynamic quantity the segmental coils and the soft iron radiating bars may be so arranged that the bars radiating from the lower disc pass under the under surface of the coils, and the radiating bars of the upper disc pass over the upper surface of the coils. Only one set of coils will then be required, but if there be 12 coils there must be 12 radiating bars in each disc.

When this galvanometer is applied to needle instruments for the sake of simplicity in construction we generally employ only two radiating bars and one inducing magnet, and instead of putting the inducing magnet at right angles to the box we place it in the same plane as the surface of the coils and cut two slots in the pole of the inducing magnet at right angles to each other, the axle carrying the soft iron disc passes between one of these slots, and the disc and radiating bars between the other.

We prefer in many cases to employ ribbon coils in place of the ordinary silk-covered wire, and as there is some difficulty in getting copper drawn down to a very thin ribbon we obtain our conductor in the following way:—We obtain a long length of very thin paper of the suitable width, and pass it through melting paraffine or other suitable insulating material; we then coat one side of it with black lead or fine metallic powder to make a conducting surface; the paper ribbon is then passed through a depositing trough, and a thin coating of copper electrotyped upon it, in this way we obtain a very thin metallic conductor. After removal from the bath the paper ribbon is washed and dried, and passed through the bath of melting paraffine again, and it is now ready for use.

To protect the coils from being damaged by lightning striking the wires we take advantage of the property possessed by powdered conducting matter when in a fine state of division offering great resistance to the passage of an electric current of moderate tension, whilst it offers comparatively but little resistance to currents of high tension. We connect the terminal of the telegraph instrument, which is connected with the line wire, to a stout piece of copper which passes into a chamber of insulating material, and terminates in a point; another piece of copper is fixed in the same chamber in close proximity to the copper point but not actually touching it. We now place finely divided powder in the chamber in sufficient quantity to cover the two pieces of copper; this second piece of copper may be either connected to the earth or to the other extremity of the insulated wire of the galvanometer coils. When lightning strikes the wires instead of passing through the convolutions of insulated wire forming the coils it will pass across the space separating the two pieces of copper, and the passage across will be further facilitated by the powder enveloping the pieces of copper. A very suitable powder is charcoal or black lead in a fine state of division, but any powder will assist the passage of high tension electricity. In some cases where we employ charcoal powder we make it red hot to drive out anything it may have absorbed, and seal the chamber up after putting it in. The absorptive power of the charcoal forms a partial vacuum which further facilitates the passage of an electric current.

We adopt the following plan when we want to obtain the most perfect protection:—We take cylinders of glass or other suitable insulating material having a hole through the centre; we grind the two ends of the hole slightly conical and of a true figuree; when turn two cylinders of metal with points at their extremities to go easily into the hole through the glass cylinders; these pointed cylinders are placed in at the ends so that the points meet at the centre of the hole in the cylindrical piece of glass; they are prevented from actually touching by shoulders cast upon the metal cylinders, which are turned conical to fit the conical ends of the hole in the cylindrical pieces of glass. To insure more perfect filling these shoulders are coated with lead or other soft metal and pressed closely against the ends of the cylindrical piece of glass by being placed between two discs and forced together by suitable bolts passing through the discs; the discs are insulated from one another. Through one of the metal cylinders there is a small hole communicating with the interior of the glass cylinder previously to bolting the parts together, sufficiently finely powdered charcoal is placed in the interior of the glass cylinder to cover the two metal points; they are then bolted together and the air pumped out of the interior of the cylinder of glass by means of an air pump and the small hole in the metal cylinder soldered or sealed up while it is connected with the air pump to prevent the re-admission of the air.

SPECIFICATION in pursuance of the conditions of the Letters Patent, filed by the said Cornelius Varley and Samuel Alfred Varley in the Great Seal Patent Office on the 17th January 1867.

TO ALL TO WHOM THESE PRESENTS SHALL COME, we, Cornelius Varley, of 337, Kentish Town Road, in the County of Middlesex, and Samuel Alfred Varley, of 66, Roman Road, Holloway, in the said County of Middlesex, Telegraph Engineers and Contractors, send greeting.

WHEREAS Her most Excellent Majesty Queen Victoria, by Her Letters Patent, bearing date the Seventeenth day of July, in the year of our Lord One thousand eight hundred and sixty-six, in the thirtieth year of Her reign, did, for Herself, Her heirs and successors, give and grant unto us, the said Cornelius Varley and Samuel Alfred Varley, Her special licence that we, the said Cornelius Varley and Samuel Alfred Varley, our executors, administrators, and assigns, or such others as we, the said Cornelius Varley and Samuel Alfred Varley, our executors, administrators, and assigns, should at any time agree with, and no others, from time to time and at all times thereafter during the term therein expressed, should and lawfully might make, use, exercise, and vend, within the United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, an Invention for "Improvements in Electric Telegraph Apparatus," upon the condition (amongst others) that we, the said Cornelius Varley and Samuel Alfred Varley, our executors or administrators, by an instrument in writing under our, or their, or one of their hands and seals, should particularly describe and ascertain the nature of the said Invention, and in what manner the same was to be performed, and cause the same to be filed in the Great Seal Patent Office within six calendar months next and immediately after the date of the said Letters Patent.

NOW KNOW YE, that we, the said Cornelius Varley and Samuel Alfred Varley, do hereby declare the nature of our said Invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement :—

Our Invention consists in an improved method of constructing single and double needle instruments and other telegraph apparatus, these improvements having for their object greater durability on the part of the instruments and less liability to derangement, either from mechanical causes or from being struck by lightning, and greater sensitiveness to feeble electric currents. We make the outer cases of our needle and other analogous telegraph instruments which heretofore have been made of wood, of cast iron, and the bush or bearing in which the axle works in one piece with the case. The axle (Fig. 4) is made of gun metal or any other suitable metal, and is constructed with a square on one end for the instrument handle to fit on to, and with a transverse piece at the other end which is usually made in a line with the handle. Two holes are bored in the upper end of the transverse piece (H, Figs. 2 and 4,) at the sides, and two insulating pins are fitted into these holes; these pins project a little way on both sides, or a piece of insulating material may be fitted in the upper end of the transverse piece as shown in Fig. 2. What is technically known as the bridge of the needle instrument (G, Figs. 1, 2, 4,) is fixed a little above the top of the transverse piece. Two upright springs (I, I,) which we call Nos. 1 and 2, press against the bridge on either side; these are attached at the lower end to blocks of metal (J, J,) and in some cases to blocks of wood. Two other upright springs called 3 and 4 are placed outside Nos. 1 and 2 springs and press against insulating pins fixed in the bridge. When the handle of the instrument is moved over to the right-hand side spring, No. 1 is removed from contact with the bridge by means of one of the insulated pins, and the lower end of the transverse piece comes against the block attached to No. 2 spring. When the handle is moved to the left-hand side spring No. 2 is removed from the bridge by the insulated pin fitted into the other side of the transverse piece. When the handle is vertical both Nos. 1 and 2 springs press against the bridge. We prefer in most cases, instead of letting the lower end of the transverse piece come in direct contact with the metal blocks, as before described, to extend the metal blocks downward some distance (four inches will be sufficient) and attach springs (K, K,) which we call Nos. 5 and 6, to the sides of the blocks for the lower end of the transverse piece to beat against, the upper parts of Nos. 5 and 6 springs come in contact with the transverse piece when the instrument handle is moved; the lower ends of these springs are attached to the bottom of the blocks. A recess is cut into the sides of the blocks to allow Nos. 5 and 6 springs to be pushed in a definite amount; their motion in the other direction is also limited by so fixing Nos. 1 and 2 springs to their respective blocks that their lower ends lap a little way over the upper ends of Nos. 5 and 6 springs. The bridge, and Nos. 1, 2, 3, 4, 5, and 6 springs, and blocks attached to them, are insulated from the iron case. The plan we prefer for doing this is to take a piece of well seasoned wood which has been soaked for a time in melted paraffine or hot linseed oil and cut a hole through it to allow the axle bush which projects a little distance in the inside of the case to pass through. We fit the blocks carrying the springs and the bridge on to this slab of wood; we then take another piece of wood of a similar size, but much thinner, and place it behind the board on which the work has been fitted. Both pieces are then placed into the cast-iron case and bolted to it. Ebonite may be employed in place of wood for insulating the different parts.

The different portions of the instrument are connected as follows:—No. 1 spring is connected to a terminal or binding screw which we call B; No. 2 spring is connected to one end of a galvanometer coil, the other end of the galvanometer coil is connected to a terminal called A; Nos. 3 and 4 springs are connected to a terminal called Z. All these terminals, with the exception of C, are insulated from the iron case.

The instrument is connected up as follows:—If the instrument be fixed at a terminal station, terminal B is connected with the line and terminal A to the earth, or vice versâ; if the instrument be placed at an intermediate station, A is connected to the line wire on one side of the station and B to the line wire on the other side of the station; terminal C is connected to the copper pole of a galvanic battery, and Z with the zinc pole of the battery. When a current is being received it passes from the line wire to terminal B, through the galvanometer (deflecting the needle) to No. 2 spring across the bridge to terminal A, and thence to the earth. When sending a current if the handle be moved to the right No. 1 spring is pressed away from the bridge and against spring No. 3, which is connected to the zinc pole of the battery. The lower end of the transverse piece which is connected through the metal case to the copper pole of the battery is brought into contact with the block of metal attached to No. 2 spring, and a positive current is sent through the galvanometer on to the line wire connected to terminal B. When the handle is moved to the left the zinc pole is brought into contact with No. 2 spring and the copper pole with No. 1 spring, and consequently a negative current passes along the line.

We construct our galvanometers (Figs. 6, 7, 8,) as follows:—We wrap the coils on frames or bobbins with moveable cheeks, so that after the coils are wrapped the bobbin on which the wire has been wrapped can be removed; these bobbins are made in the shape of segments of a circle. After the coils have been wrapped they are immersed for a time in a bath of any suitable melting cement; they are then removed from the bath and the bobbins carefully taken to pieces, the wires retaining their position by the adhesion of the cement. The coils are then placed in a mould of the shape the coils are intended to be when finished and compressed; this brings the convolutions closer together and forms them into segments of a circle; when the cement has hardened by being cooled the coils are removed from the mould and placed in a circular chamber or box, the coils being segments of a circle pack closely together, as shown in Fig. 6. The coils are of such a length that they do not reach to the centre of the circular box but leave a central space; in this space and at right angles to the circular box the pole of a powerful permanent magnet is inserted. A circular soft iron disc with soft iron bars radiating from it (Figs. 9, 10,) is mounted on an axle over the pole of the permanent magnet, which may be a compound magnet, as shown in Figs. 7 and 8. The radiating bars are made of even numbers, so that they may be opposite one another and pass over the surface of the segmental coils; the axle terminates in a fine pivot which works in a pivot hole made in the pole of the permanent magnet. The soft iron disc and its radiating bars become magnetic by induction from the permanent magnet underneath, and all the bars being magnetized in a similar way they are practically astatic. To prevent the friction in the pivot hole, which would be caused by the inducing magnet pulling the iron disc towards it, a second iron disc (Fig. 10) with radiating bars exactly similar to that before described is mounted on the same axle higher up; this second disc is so mounted on the axle that if a perpendicular line be dropped from the upper radiating bars when the axle is vertical it will pass exactly between the bars radiating from the lower disc. Over the upper disc another permanent magnet is mounted which magnetizes it and the bars radiating from it by induction, and there is also an arrangement by means of which the pole of the upper permanent magnet can be adjusted nearer or further from the upper disc by raising or lowering this adjustment; the attractive forces of the upper and lower permanent magnets on the soft iron discs can be balanced. The number of radiating bars in each disc is half that of the coils, that is to say, if there be twelve segmental coils, each occupying a space of 30 degrees, there will be six radiating bars in each disc 60 degrees apart from one another on their respective discs. The lower soft iron disc is generally mounted below the surface of the coils, and the radiating bars are first bent at right angles or nearly so to the disc and then bent again so as to move in a plane over the surface of the coils, as shown in Fig. 8. The radiating bars of the upper disc are also bent, so that they move in the same plane over the surface of the coils as the radiating bars of the lower disc and being exactly between them the distance between the radiating bars of the upper and lower discs is 30 degrees, and consequently there is a radiating bar over each coil. The inducing pole of the upper permanent magnet is of the opposite polarity to that of the lower permanent magnet, the radiating bars are therefore magnetized alternately north and south. The segmental coils are also so joined up that when an electric current is sent through them the centres of the coils become alternately south and north. A second series of segmental coils can be arranged over the upper surface of the radiating bars to increase the force of the electric currents. When an electric current is sent through the coils the radiating bars arrange themselves over the centres of the coils according to the direction of the electric current, and being highly magnetic and at the same time not influenced by the earth's magnetism the instrument is very sensitive. The sensitiveness of the instrument can be still further increased by fixing a mirror on the axle carrying the discs and reflecting a beam of light on a screen. In some cases we make the radiating bars of magnetized tempered steel and do away with the inducing magnets, but where great sensitiveness is required we prefer using soft iron radiating bars and inducing magnets, and when we desire the greatest possible sensitiveness we replace the permanent inducing magnets by electro-magnets. This galvanometer forms a very good relay for working Morse printing instruments or for relay transmission; when we use it for this purpose we mount a light metallic arm on the axle carrying the soft iron discs, having a piece of platina or platina alloy fixed to it where it touches the contact points. This relay works between two contacts in a similar way to what are known by the name of polarized relays, but instead of using fixed points for the relay arm to beat against we mount small wheels or rollers made of gold or platina alloy (Fig. 13), motion is communicated to these wheels by two hard rollers made of bell metal or other hard non-magnetic metal rolling against them; these bell metal rollers are driven by preference by means of a simple piece of clockwork, which we prefer being made entirely of brass or other non-magnetic metal.

The gold rollers revolve in the same plane as the relay lever, and when the contact lever beats against them any film of air adhering to the roller is wiped away and better contact made, the lever is also less liable to stick than in other relays when working with very weak currents. The object of communicating the motion by another roller is that it burnishes down the roughness caused by the electric current melting the metal at the point of contact; this method of making contact is applicable to nearly all relays. When the galvanometer is intended for currents of large dynamic quantity the segmental coils and the soft iron radiating bars may be so arranged that the bars radiating from the lower disc pass under the under surface of the coils, and the radiating bars of the upper disc pass over the upper surface of the coils. Only one set of coils will then be required, but if there be twelve coils there must be twelve radiating bars in each disc. When this galvanometer is applied to needle instruments for the sake of simplicity in construction we generally employ only two radiating bars and one inducing magnet, and instead of putting the inducing magnet at right angles to the box we place it in the same plane as the surface of the coils and cut two slots in the pole of the inducing magnet at right angles to each other, the axle carrying the soft iron disc passes between one of these slots and the disc and radiating bars between the other. The inducing magnet may be arranged vertically, and if only one radiating bar be used ordinary galvanometer coils very similar to those used in Cooke & Wheatstone's needle telegraph instrument may be employed, which possess the advantage of greater simplicity in construction. We prefer in many cases to employ ribbon coils in place of the ordinary silk covered wire, and as there is some difficulty in getting copper drawn down to a very thin ribbon we obtain our conductor in the following way:—We obtain a long length of very thin paper, of the suitable width, and pass it through melting paraffine or other suitable insulating material; we then coat one side of it with black lead or fine metallic powder to make a conducting surface; the paper ribbon is then passed through a depositing trough and a thin coating of copper electrotyped upon it; in this way we obtain a very thin metallic conductor. After removal from the bath the paper ribbon is washed and dried and passed through the bath of melting paraffine again and it is now ready for use. To protect the coils from being damaged by lightning striking the wires we take advantage of the property possessed by powdered conducting matter, when in a fine state of division, of offering great resistance to the passage of an electric current of moderate tension, whilst it offers comparatively but little resistance to currents of high tension. We connect the terminal of the telegraph instrument which is connected with the line wire to a stout piece of copper, which passes into a chamber of insulating material and terminates in a point; another piece of copper is fixed in the same chamber in close proximity to the copper point, but not actually touching it; we now place finely divided powder in the chamber, in sufficient quantity to cover the two pieces of copper; this second piece of copper may be either connected to the earth or to the other extremity of the insulated wire of the galvanometer coils. When lightning strikes the wires instead of passing through the convolutions of insulating wire forming the coils it will pass across the space separating the two pieces of copper, and the passage across will be farther facilitated by the powder enveloping the pieces of copper. A very suitable powder is charcoal or black lead in a fine state of division, but any powder will assist the passage of high tension electricity. In some cases where we employ charcoal powder we make it red hot to drive out anything it may have absorbed and seal the chamber up after putting it in; the absorptive power of the charcoal forms a partial vacuum, which further facilitates the passage of an electric current. We adopt the following plan when we want to obtain the most perfect protection:—We take cylinders of glass (Fig. 16) or other suitable insulating material having a hole through the centre; we grind the two ends of the hole slightly conical and of a true figure; we then turn two cylinders of metal with points at their extremities to go easily into the hole through the glass cylinders; these pointed cylinders are placed in at the ends so that the points meet at the centre of the hole in the cylindrical piece of glass; they are prevented from actually touching by shoulders cast upon the metal cylinders, which are turned conical to fit the conical ends of the hole in the cylindrical pieces of glass. To ensure more perfect fitting these shoulders are coated with lead or other soft metal and pressed closely against the ends of the cylidrical piece of glass by being placed between two discs and forced together by suitable bolts passing through the discs; the discs are insulated from one another. Through one of the metal cylinders there is a small hole communicating with the interior of the glass cylinder, previously to bolting the parts together powdered charcoal or other suitable powder is placed in the interior of the glass cylinder to cover the two metal points; they are then bolted together and the air pumped out of the interior of the cylinder of glass by means of an air pump, and the small hole in the metal cylinder soldered or sealed up while it is connected with the air pump to prevent the re-admission of the air.

DESCRIPTION OF THE DRAWINGS.

The same letters refer to the same parts in all the Figures.

Fig. 1 represents a side view of a single needle instrument with one side removed to shew the interior; Fig. 2 represents a back view of the same instrument with the back removed; Fig. 3 is a front view of the instrument. A, B, are the two line wire terminals; D, D, D, is the iron case; D^1 is the bush in which the axle works; E is the handle; G is the bridge; G^1 is a pin made of insulating material which prevents No. 3 and 4 springs coming in contact with the bridge; H, H, is the transverse piece; H^1 is a piece of insulating material fitted into the upper end of the transverse piece, and comes into contact with Nos. 1 and 2 springs accordingly as the handle is moved to the right or to the left. I, I, are Nos. 1 and 2 springs attached to the blocks J, J; K, K, are Nos. 5 and 6 springs attached to the lower end of the same blocks; these springs and blocks are shewn separate in Fig. 5. L, L, are Nos. 3 and 4 springs connected by means of a wire M, M, M, together, and also with a terminal in connection with the zinc pole of the battery; N, N, are the galvanometer coils; O, O, is the inducing magnet formed of two permanent bar magnets; P, P, are two terminals to which the ends of the insulated wire forming the coils are connected; Q, Q, Q, are connecting wires forming the connections between the line wire terminals and the galvanometer; R is a spring or a piece of wire rope in metallic connection with the axle, and also with the terminal in connection with the copper pole of the battery. The battery terminals are not shewn in the Drawings. S is the lightning protector shewn separate from the instrument and connected to the line terminals A and B, as indicated by the dotted lines.

Fig. 4 represents a side view of the apparatus and part of the instrument separate.

Figs. 6, 7, 8, 9, 10, shew the construction of our galvanometer in its most sensitive form. Fig. 6 is a top view with the radiating bars and inducing magnets removed, shewing the arrangement of the segmental coils; Fig. 7 is a side view; Fig. 8 is a side view in section with the framework to which the induced magnets are attached removed; Figs. 9 and 10 represent a top view of the soft iron discs with their radiating bars separated from the axle. N, N, N, N, N, N, N, N, N, N, N, N, are the coils; T is a brass box containing the coils; U is a brass frame attached to the brass box T; V, V, V, V, V, V, V^1, V^1, V^1, V^1, V^1, V^1, are the radiating bars; O is the upper inducing magnet; O^1 is the lower inducing magnet; W is a soft iron screw which screws into the block of iron W^1 on which the upper inducing magnet rests. By screwing this soft iron screw up or down the attractive forces of the upper and lower inducing magnets on the soft iron discs are balanced. X is the axle on which the discs and radiating bars are mounted.

Fig. 11 represents our method of making relay contacts. Y is the relay contact lever; Z, Z, are the two contact rollers; Z^1, Z^1, are the two driving rollers.

Figs. 12, 13, 14, 15, shew the construction of the simple but less sensitive forms of the galvanometer. Fig. 12 is a front view with frame removed shewing the inducing magnet coils and radiating bars; Fig. 13 is a side view of the same; Figs. 14 and 15 shew the construction of the galvanometer with the inducing magnet arranged vertically instead of horizontally; Fig. 14 shows the framework of the galvanometer with the coils removed. a, a^1, is a coil frame being similar to those empolyed in the ordinary Cooke & Wheatstone's needle telegraph instrument. The upper pillar of the frame a^1 is made of iron and passes through the dovetail slide b. A plate of soft iron $a1$ depends from the iron pillar, and is slotted as shewn in the Fig. . The object of this plate is to conduct the magnetism to the radiating bar V, one end of which works in the slot in the soft iron plate. The axle passes through the radiating bar near one end, as shewn in the Figure. The inducing magnet is placed at the back of the instrument and bolted to it by a soft iron bolt which passes through the back and projects a little way inside. The upper pillar of the frame rests upon the soft iron bolt, and magnetism is communicated by induction from the permanent magnet through the soft iron bolt to the upper pillar, and thence to the soft iron radiating bar. The coils used in this arrangement are very similar to those in the ordinary Cooke & Wheatstone's needle telegraph.

Fig. 15 shews a very similar construction to that just described, but with the inducing magnet inside of the instrument. $b1$, $b1$, is the outer side coil cheek of the galvanometer coil; b^2, b^2, is the inside cheek of the coil, which is extended a little below the outer one. A piece of soft iron o^1 is let into the inside cheeks of the coils, and the permanent inducing magnet is screwed against this piece of soft iron, making it magnetic by induction, and also the soft iron radiating bar mounted on the axie which works between the middle of the coils. This construction of the galvanometer is shewn in two other positions in Figs. 1 and 2.

Fig. 16 shews the method of constructing our lightning protectors when we want to obtain the greatest amount of protection. c, c, is the glass cylinder; d, d^1, are the two cylinders of metal with conical shoulders; the dotted lines in the centre of d^1 represent the hole communicating with the interior of the glass cylinder.

Figs. 17 and 18 represent our method of magnetizing our permanent magnets. *e*, *e*, e^1, e^1, are two hollow electric magnets made by grooving out forked pieces of soft iron and placing them together, as shewn in the Figures. The dotted lines *f*, *f*, *f*, *f*, represent the coils of the electro-magnets. The magnets are arranged so that the north pole of the one is opposite to the south pole of the other, and vice versa. The hardened steel bars intended to be magnetized are placed in the centre of the electro-magnets and shifted backwards and forwards between the poles of the two electro-magnets. Two steel bars can be magnetized at the same time by this arrangement.

Having thus described the nature of the said Invention, and in what manner the same is to be performed, we wish it to be understood what we claim is,—

First, constructing the cases of needle and other analogous telegraph instruments of cast iron with the bush in one solid piece with the case, and the general construction of the working parts of the needle telegraph instrument as herein-before described.

Second, the general construction of the galvanometer, Fig. 6, 7, and 8, and the modifications of the same, as described.

Third, the substitution of moving in place of fixed contacts for relay contact levers to beat against, and the method of doing the same, as herein-before described.

Fourth, the facilitating the passage of lightning between two conductors in proximity to one another by filling the space between with matter in a fine state of division, as herein-before described.

Fifth, the method of constructing lightning protectors where a vacuum is employed in conjunction with matter in a fine state of division, as described.

In witness whereof, we, the said Cornelius Varley and Samuel Alfred Varley, have hereunto set our hands and seals, this Seventeenth day of January, One thousand eight hundred and sixty-seven.

CORNELIUS VARLEY. (L.S.)
SAMUEL ALFRED VARLEY. (L.S.)

LONDON:
Printed by George Edward Eyre and William Spottiswoode,
Printers to the Queen's most Excellent Majesty. 1867.

A. D. 1866. July 17. No 1867.
C. & S. A. VARLEY'S Specification.

(1 SHEET.)

FIG. 17.

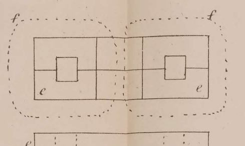


FIG. 9.

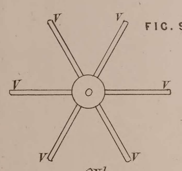


FIG. 10.

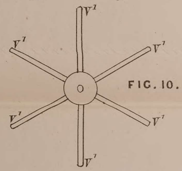


FIG. 18.

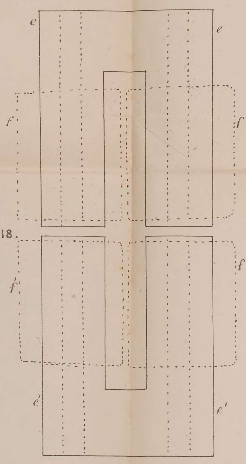


FIG. 6.

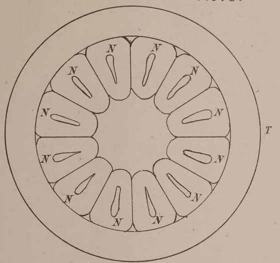


FIG. 16.

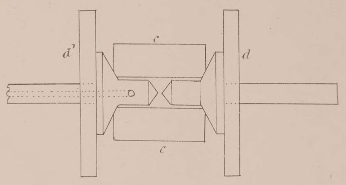


FIG. 8.

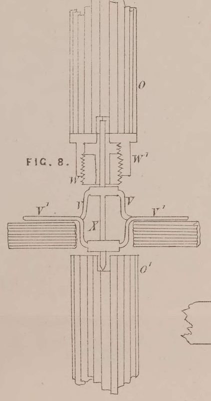


FIG. 7.

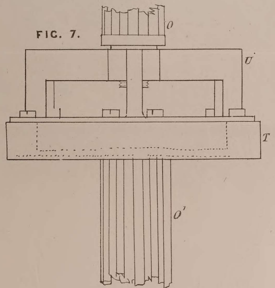


FIG. 12.

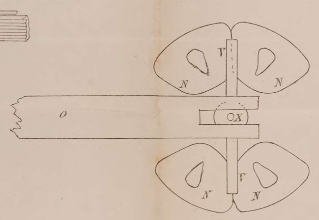


FIG. 13.

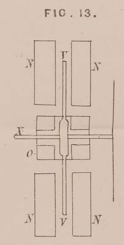


FIG. 14.

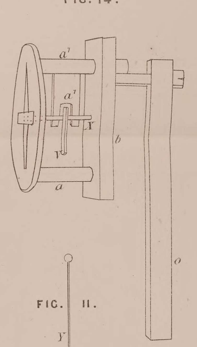


FIG. 11.

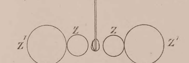


FIG. 3.

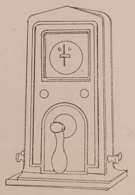


FIG. 2.

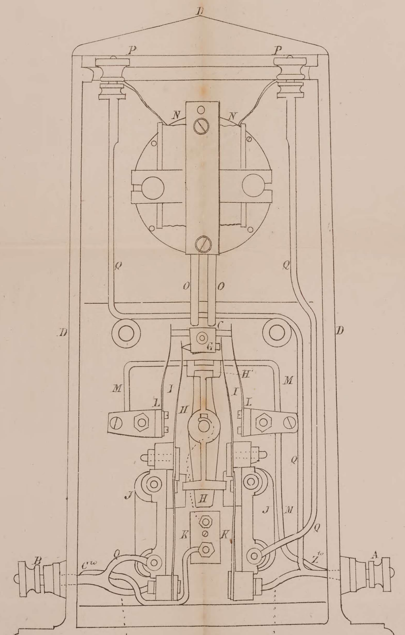


FIG. 1.

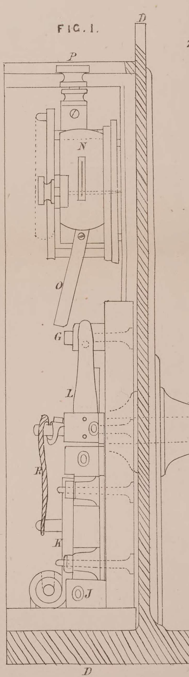


FIG. 15.

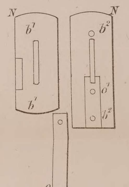


FIG. 4.

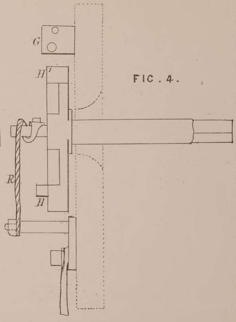
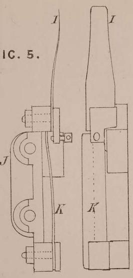


FIG. 5.



The filed drawing is colored.

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